Geophysical Research Abstracts
Vol. 21, EGU2019-16387, 2019
EGU General Assembly 2019

Slow to fast paces of convection in magmatic systems

Chiara P Montagna (1) and Federico Brogi (1,2)

(1) Istituto Nazionale di Geofisica e Vulcanologia, sezione di Pisa, Italy (chiara.montagna@ingv.it), (2) Istituto Nazionale di Oceanografia e di Geofisica Sperimentale,Sgonico, Italy

Convective flows are common in volcanic feeding systems at various depths, from low-melt-fractions mush reservoirs to melt-dominated storage zones to sub-aerial lava lakes (e.g., Bergantz et al., 2015; Forni et al., 2016; Montagna and Papale, 2018; Spera and Bohrson, 2018; Valade et al., 2018). Convection plays a pivotal role in determining the thermal and chemical evolution of magmas in the Earth's crust, being one of the main processes associated with magmatic dynamics.

Within the magmatic realm, convective processes can be either natural or forced, diffusion- or buoyancy-dominated. Their length and time scales can span orders of magnitude and be more or less effective in terms of mass, momentum and energy exchange. Convective dynamics can modify the physical properties of magmas, and are in turn largely impacted by them, resulting in potentially important feed-backs. The interplay between density and viscosity of magmatic mixtures, including effects due to volatile and crystal contents, chemical and thermal diffusion time scales, as well as temperature and depth of the intrusive bodies, can define a variety of paths to re-equilibration that are reflected into very different magmatic histories.

The convective regimes pertaining to magmatic systems can be identified by relevant adimensional numbers, such as Rayleigh and Atwood, and dimensional characteristic quantities. We performed a set of numerical simulations in different regimes in order to define the conditions for effective convection to take place, and the parameters that govern its length and time scales. Preliminary results reveal that buoyancy-driven reservoir-wide natural convection can be significant on relatively short time scales for volatile-rich mafic recharge into more felsic reservoirs. On the other hand, melts and magmas of larger viscosities tend to create boundary layers that evolve on longer time scales, and suppress larger scale motion. The role of volatiles, especially water, is particularly significant, as even small variations in their contents strongly affects fluid viscosity.

As convection strongly enhances mechanical mixing between magmas, these results can guide the interpretation of chemical heterogeneities observed in magmatic and plutonic bodies, such as large spread in zircon-derived ages or significant differences in isotopic compositions, that are sometimes observed in both the plutonic and magmatic records (e.g., Larderello-Travale, Yellowstone: Dini et al., 2005; Farina et al., 2018; Wotzlav et al., 2014).